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13. ABSTRACT (*Maximum 200 words*)

THIS IS A PROGRESS REPORT ON AEROJETS' STUDIES OF EXPERIMENTS CURRENTLY UNDERWAY (E.G., PLANT GROWTH AND DIMP AND DCPD LYSIMETER TESTS). TESTS ARE STILL IN PROGRESS TO DETERMINE THE STABILITY OF DIMP AND DCPD IN INTIMATE CONTACT WITH TOP SOIL. THE FIVE DIFFERENT SOILS HAVE BEEN OBTAINED FOR USE IN THE LYSIMETER TEST. FOUR HAVE BEEN PROCESSED FOR TEACHING EXPERIMENTS, THE FIFTH IS CURRENTLY BEING LOADED. THE PLANTS DESCRIBED IN THE LAST MONTHLY REPORT HAVE BEEN EXPOSED TO DIMP FOR 44 DAYS AND TO DCPD FOR 39 DAYS. IN THE MOST RECENTLY REVISED PROTOCOL, THE PLANT GROUPINGS HAVE BEEN MODIFIED AND AN ADDITIONAL GROUP, AQUATIC PLANTS, HAS BEEN ADDED. A LICENSE HAS BEEN GRANTED TO POSSESS RADIOACTIVE MATERIAL (40 MILLICURIES OF CARBON-14) FOR USE IN PLANT TRACER STUDIES).

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DETERMINATION OF DECONTAMINATION CRITERIA

DIMP AND DCPD (U)

Report No. 1953-01-(05)MP

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U.S. ARMY, Ft. Detrick
Fredrick, Maryland 21701

Prepared by: P.A. O'Donovan
P.A. O'Donovan

Date: 4 December 1975

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Progress on items proposed for action during November 1975, is discussed in the following paragraphs.

SOIL/AGENT COMPATABILITY TESTS

Tests are still in progress to determine the stability of DIMP (diisopropyl methyl phosphonate) and DCPD (dicyclopentadiene) in intimate contact with Chino top soil.

The analytical methods used in this study have been discussed previously. Data from these tests to date is shown in Table 1.

Figure 1 is a plot of all the data in Table I. To simplify the graph, the average of the five concentrations were plotted against time giving the graph in Figure 2.

Because of the relative facility of their analysis the DIMP samples are being processed more rapidly resulting in data such as the above. Chromatographic schemes for the analyses of the DCPD samples are being investigated. Until reliable performance can be demonstrated by these methods at the low concentration levels of interest here the DCPD samples are being held in refrigerated storage. These will be analyzed when the assay method is completely developed.

The original assumption that an initial rapid loss of agent, at least in the case of DIMP, is followed by a more gradual plateauing seems to still be valid.

Further sampling and analysis of these specimens is continuing.

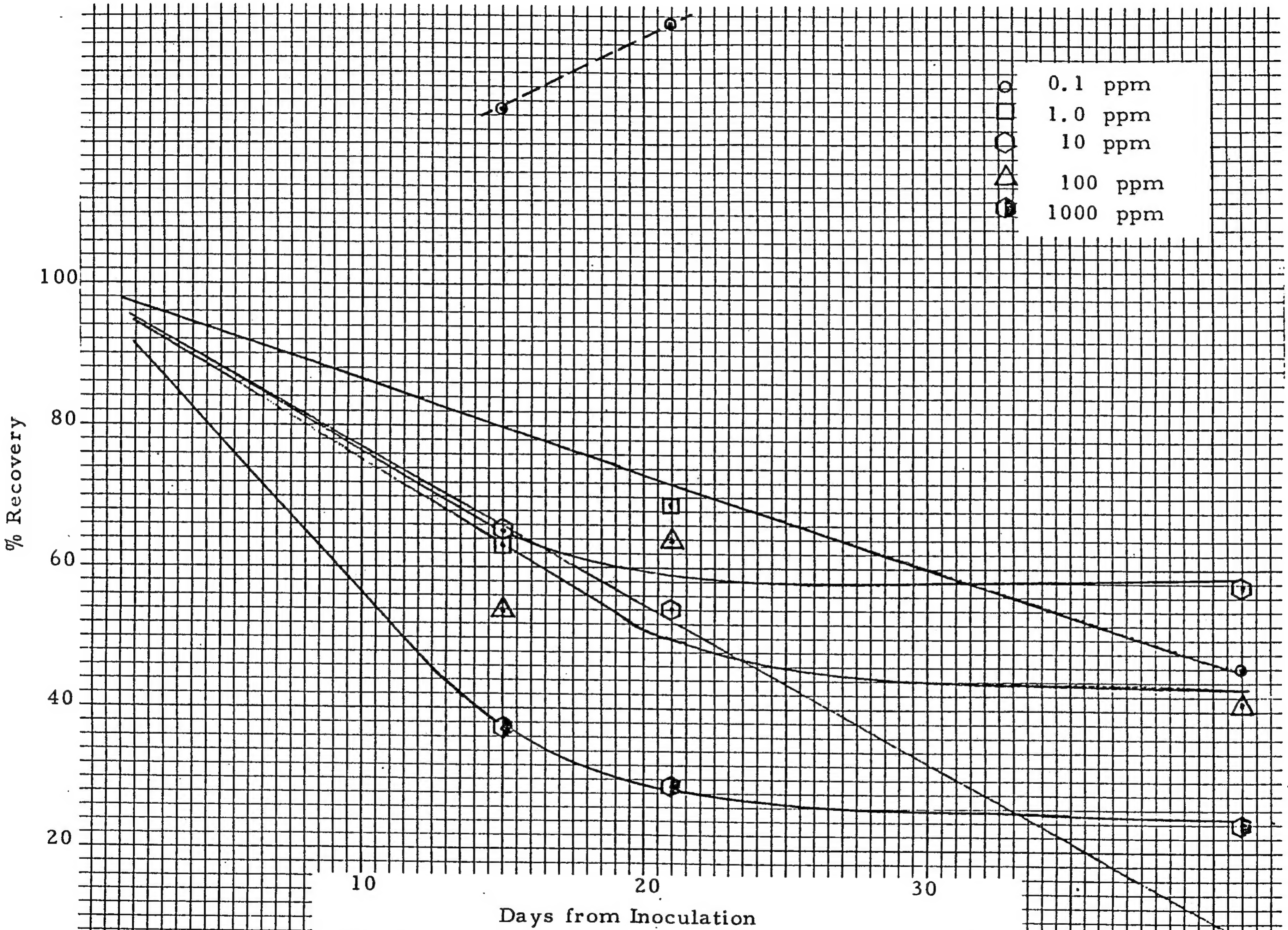

Figure 1. Recovery of DIMP from Intimately Mixed Soil Samples

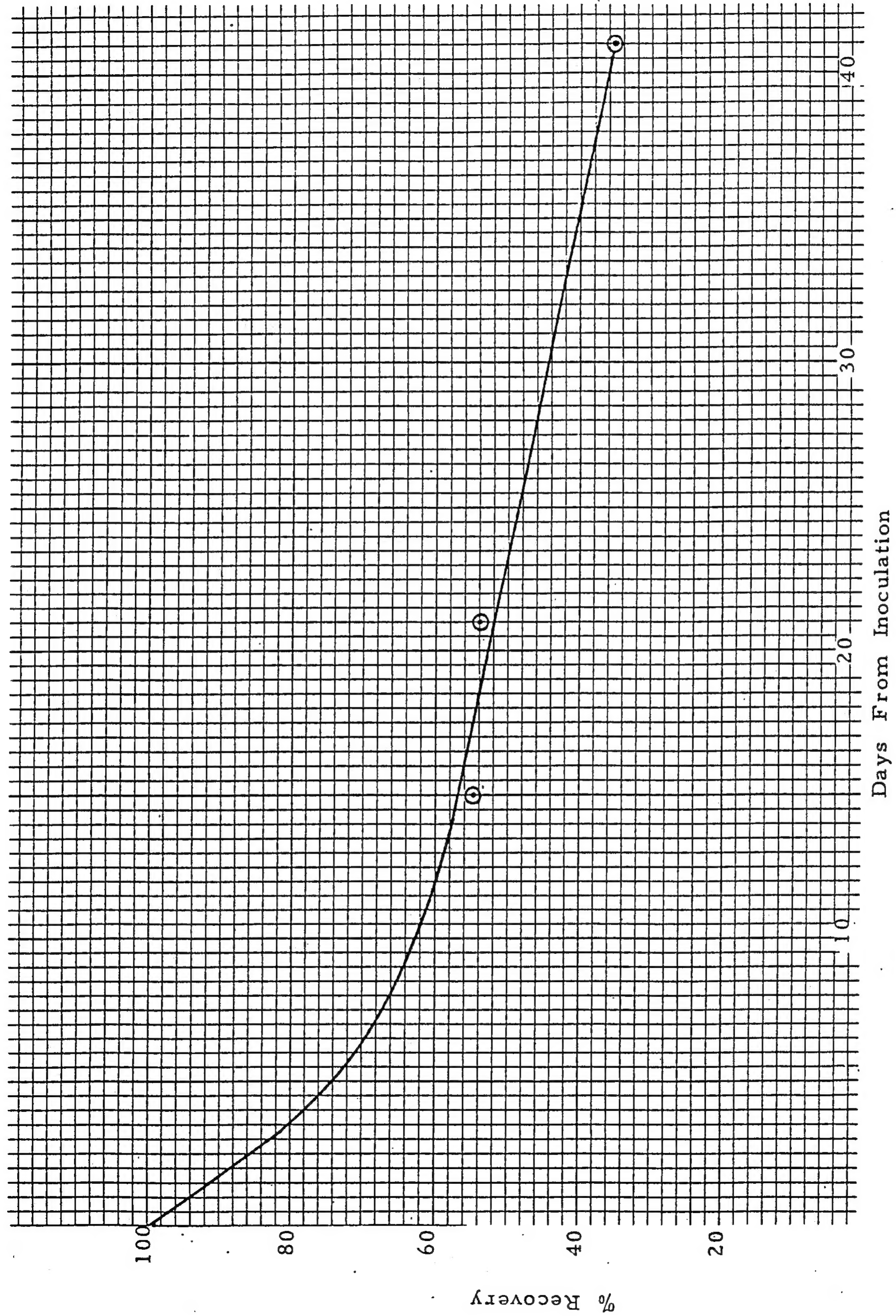

Figure 2. Average Recovery of DIMP from Intimately Mixed Soil Samples.

PREPARATION OF FULL SCALE LYSIMETER TESTS

The five different soils have been obtained for use in the lysimeter tests. Four of them have been processed and loaded into lysimeters(2 each) for DIMP and DCPD leaching experiments. These lysimeters have been conditioned and are ready for inoculation. The fifth soil is currently being loaded. It is anticipated that the inoculation of all five types of soil will take place in December.

Soil number four was procured at Fullerton, California and is a sandy loam which is the closest to the type encountered at Rocky Mountain Arsenal. The fifth soil comes from the Walnut, California area.

Characterizational analysis is still underway for some of the soils. Preliminary data relative to this is shown in Table II. The soil type classification of the first three soils is shown in Figure 3 and the geographical location of the five soil samples is shown in Figure 4.

Table 1

Recovery of DIMP from Top Soil Samples

DIMP Concentration (Calc.) (ppm)	% of DIMP Concentration Found in Soil		
	After 15 Days	After 21 Days	After 41 Days
0.1	125	137	46.0
1.0	63	69	7.6
10.0	65	54	57.9
100.0	54	64	41.0
1000.0	37	29	24.0
Average	54.75	54.0	35.3

Table II

Characterization of Lysimeter Sample Soils

Soil Source	pH	Organic Matter (%)	Sand (%)	Silt (%)	Clay (%)	Moisture Capacity (%)
Chino	5.6	2.8	49	26	25	45.4
Brawley	7.9	*	16	25	59	49.8
Ventura	7.1	*	31	42	28	45.1
Fullerton	*	*	*	*	*	*
Walnut	*	*	*	*	*	*

* Assay data unavailable at this writing

(1) Chino
(2) Brawley
(3) Ventura

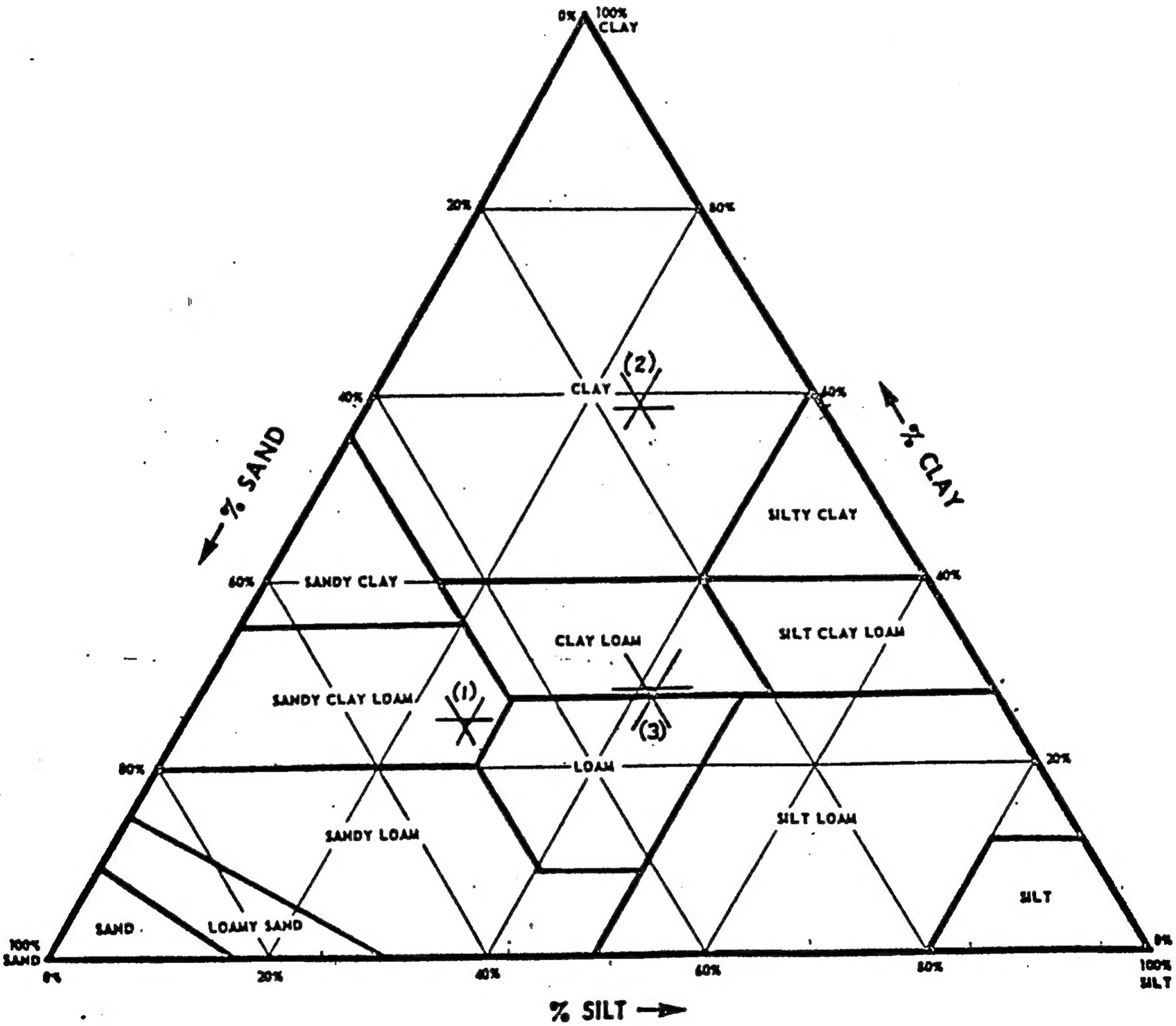

Figure 3. Textural Classification of Soils.

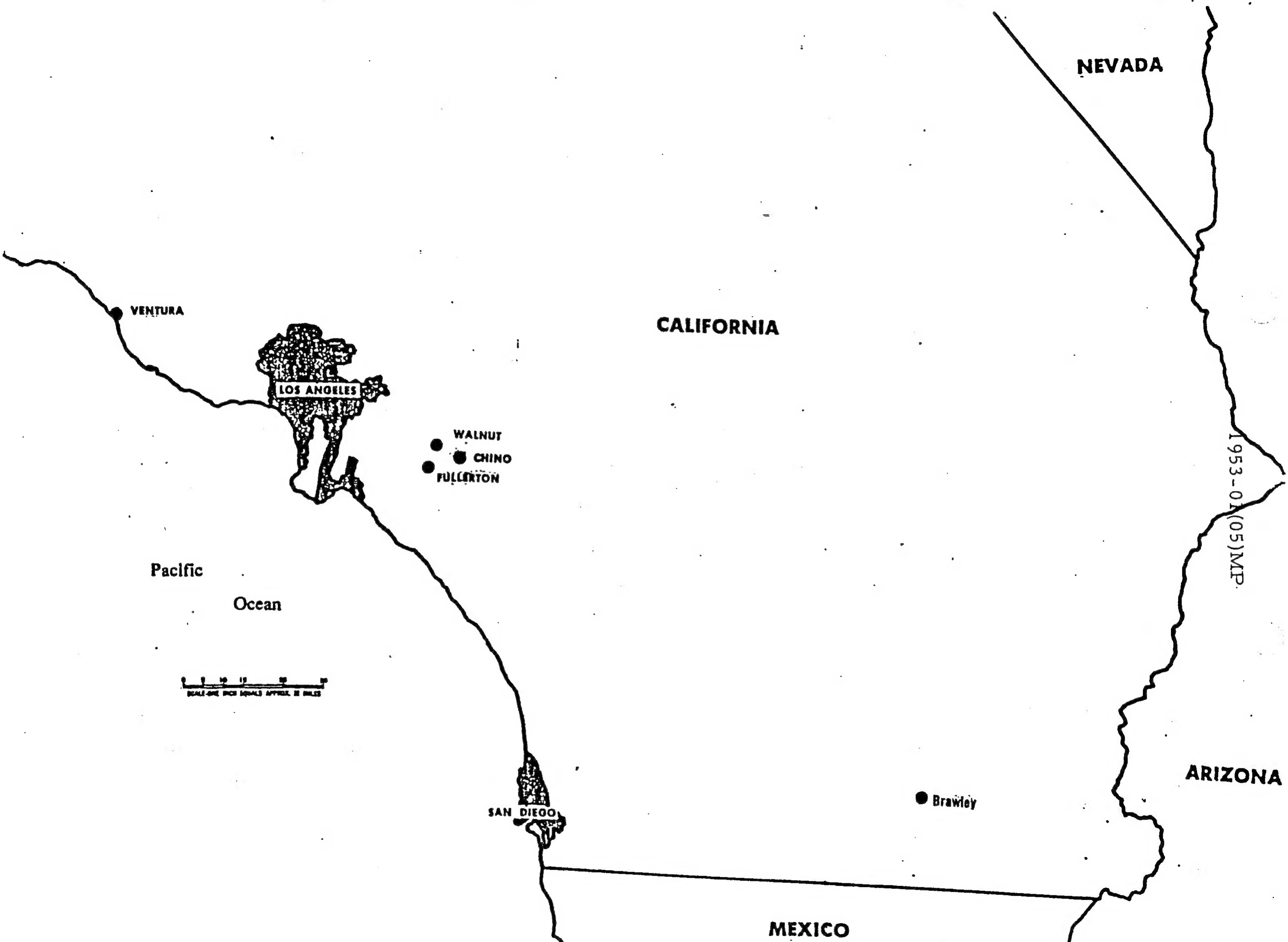

Figure 4. Geographical Location of AOMC Lysimeter Samples

RANGE FINDING PLANT GROWTH EXPERIMENTS

The plants described in the last monthly report have been exposed to DIMP for 44 days and to DCPD for 39 days at this writing. The agent levels in the nutrient baths have been brought up to their original levels several times throughout the experiment and various plants and plant parts have been sacrificed and analyzed.

After 22-25 days all of the plants in the 1000 ppm DIMP nutrients, except for the juniper, showed various stages of necrosis, all quite severe and the entire plants were retrieved and analyzed for DIMP content. The plants were divided into leaves, stems and roots and these were analyzed individually. Table III shows the DIMP content of the plants as ppm by weight of the fresh plant material.

It can be seem from Table III that bio-accumulation of DIMP does occur in some plants at this concentration level and that generally the leaves are the repositories of the greatest amount of contaminant. All but three of the plants show levels of DIMP in excess of that in the nutrient medium. The accumulation factors overall ranged from 0.05 x to 15 x. The stems and roots, in general showed less accumulation than the leaves and the more woody plants showed greater accumulation than the softer plants.

Figures 5 and 6 are plots of the data in Table III. The difference between leaves, stems and roots is quite apparent except in the case of corn where the leaves and stem are approximately equal. This might be expected due to the similarity between the leaf and stem tissues in the corn plant. The juniper has data only for the leaves, since the plant was apparently healthy it was decided to continue its exposure for a longer period to await possible symptoms of phytotoxicity.

Table III

DIMP Content of Plant Parts (ppm)
(from 1000 ppm Nutrient, 22-25 days exposure)

Plant Type	Leaves	Stem	Root
Tomato **	15,213	3,040	4,674
Corn	8,918	8,993	1,703
Bean	8,000	2,018	729
Radish	5,231	1,000	2,935
Fescue	2,329	134	208
Sugar Beet	1,851	208	30
Carrot	1,137	541	52
Rose	613	42	136
Wheat	192	*	3
Juniper	53	*	*

* Not Processed

** 15 Days

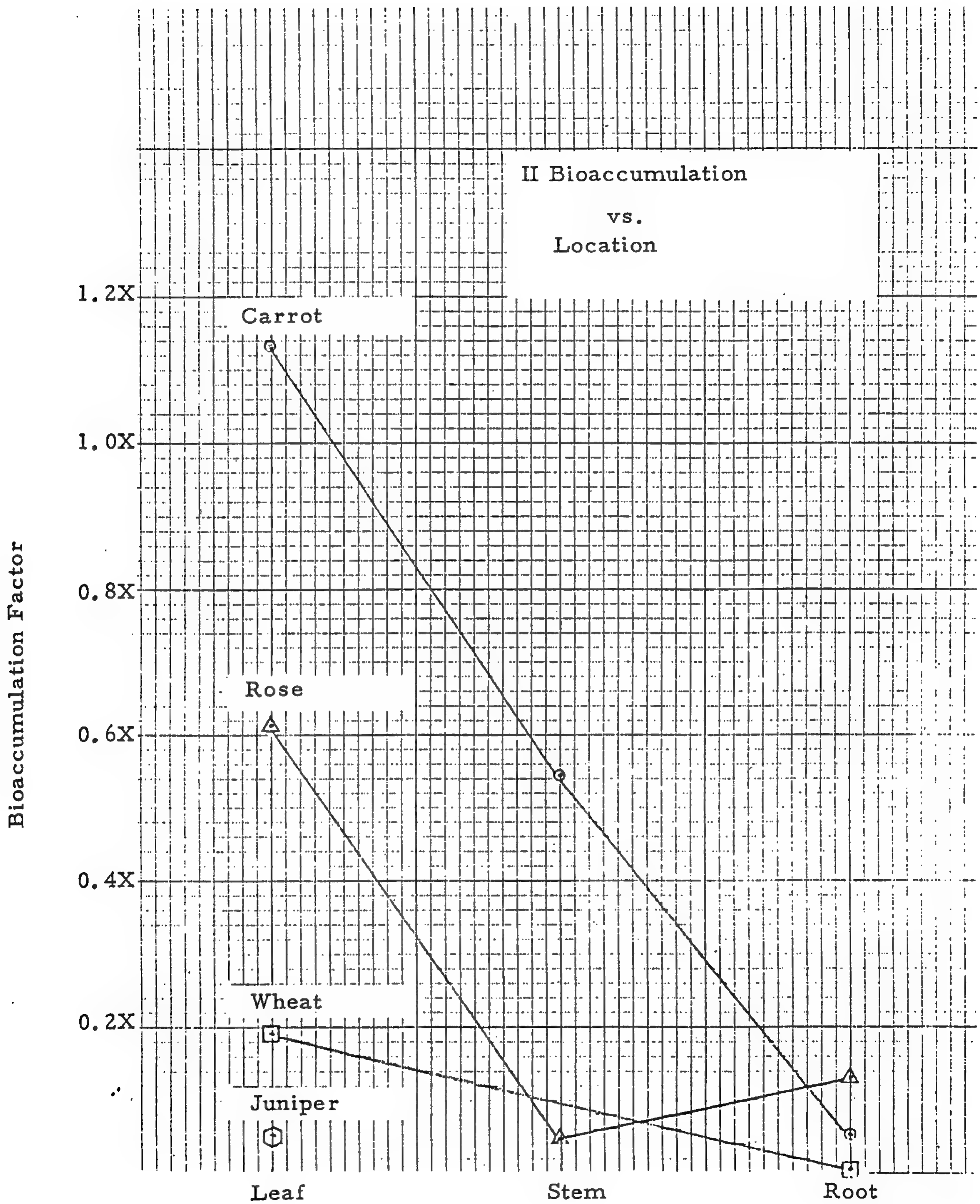

Figure 5. Bioaccumulation of DIMP in Plant Parts from 1000 ppm Contaminated Nutrient.

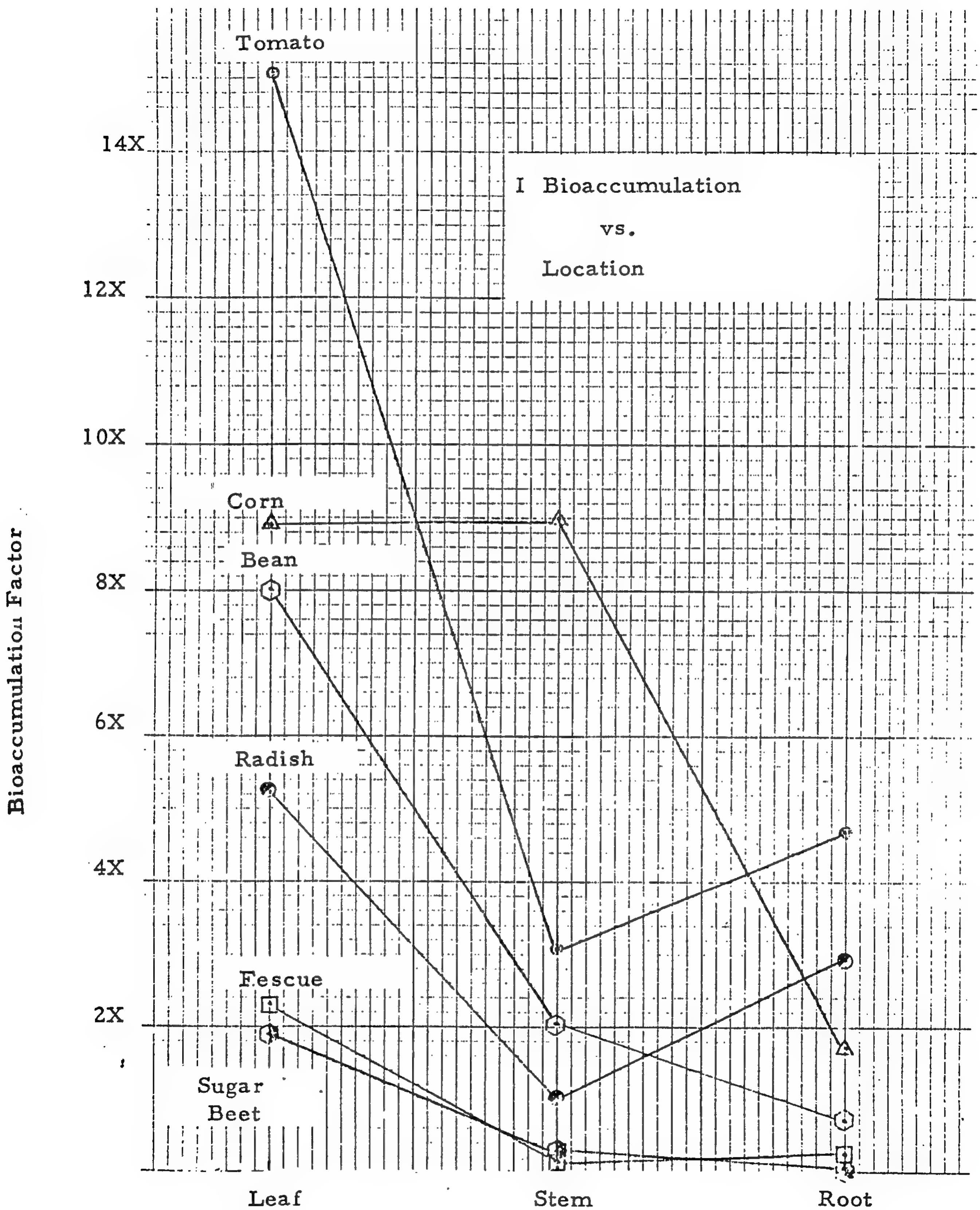

Figure 6. Bioaccumulation of DIMP in Plant Parts from 1000 ppm Contaminated Nutrient.

The growth of radishes from each of the concentration levels of both DIMP and DCPD was terminated and the plants dissected, weighed and analyzed for DIMP. The DCPD samples were again stored under refrigeration for future analysis.

For purposes of differentiatian the radish was divided into three parts; the edible portion of the root referred to here as fruit, the remaining hairy portion of the root referred to here as root and the green portion referred to here as leaves.

The weights of the various portions at harvest are shown in Table IV.

Plotting the data from Table IV gives the curves in Figures 7 and 8 . It will be noted here that there is a distinct difference in the effects of DIMP and DCPD on the plants. Lower levels of DIMP (1, 10 ppm) have a growth enhancing effect which is overcome by higher levels of contaminant (100, 1000 ppm) which lead to subnormal growth and death. Visible symptoms of systemic toxicity (leaf burn, leaf curling, withering, etc.) are more obvious in the case of DIMP contamination while the DCPD seems to have more of a stunting effect without the immediate systemic manifestations. This could be expected from the relatively high solubility of the DIMP in the nutrient medium and the almost zero solubility of the DCPD which coats the contacted root surfaces with an oily/waxy film.

A chromatographic analysis of the radish parts for DIMP content gave the data shown in Table V.

Figure 9 is a plot of the data in Table V. It can be seen that in most cases an accumulating effect is present, much greater in the leaves than in the rest of the plant.

Table IV

Yield of Radish Plants from Various
Nutrient Levels of Contamination

Type and Level of Contamination	Weight of Plant Part (g) Root	Fruit	Leaves
DIMP Control	5.2	43.1	16.7
" 1.0 ppm	0.8	51.2	14.4
" 10.0 ppm	3.2	82.2	32.8
" 100 ppm	1.7	24.3	9.9
" 1000 ppm	0.05	0.13	0.29
DCPD Control	2.0	74.6	30.8
" 1.0 ppm	2.3	58.8	20.5
" 10.0 ppm	1.2	66.4	21.2
" 100 ppm	0.6	30.7	11.0
" 1000 ppm	1.2	17.6	12.5

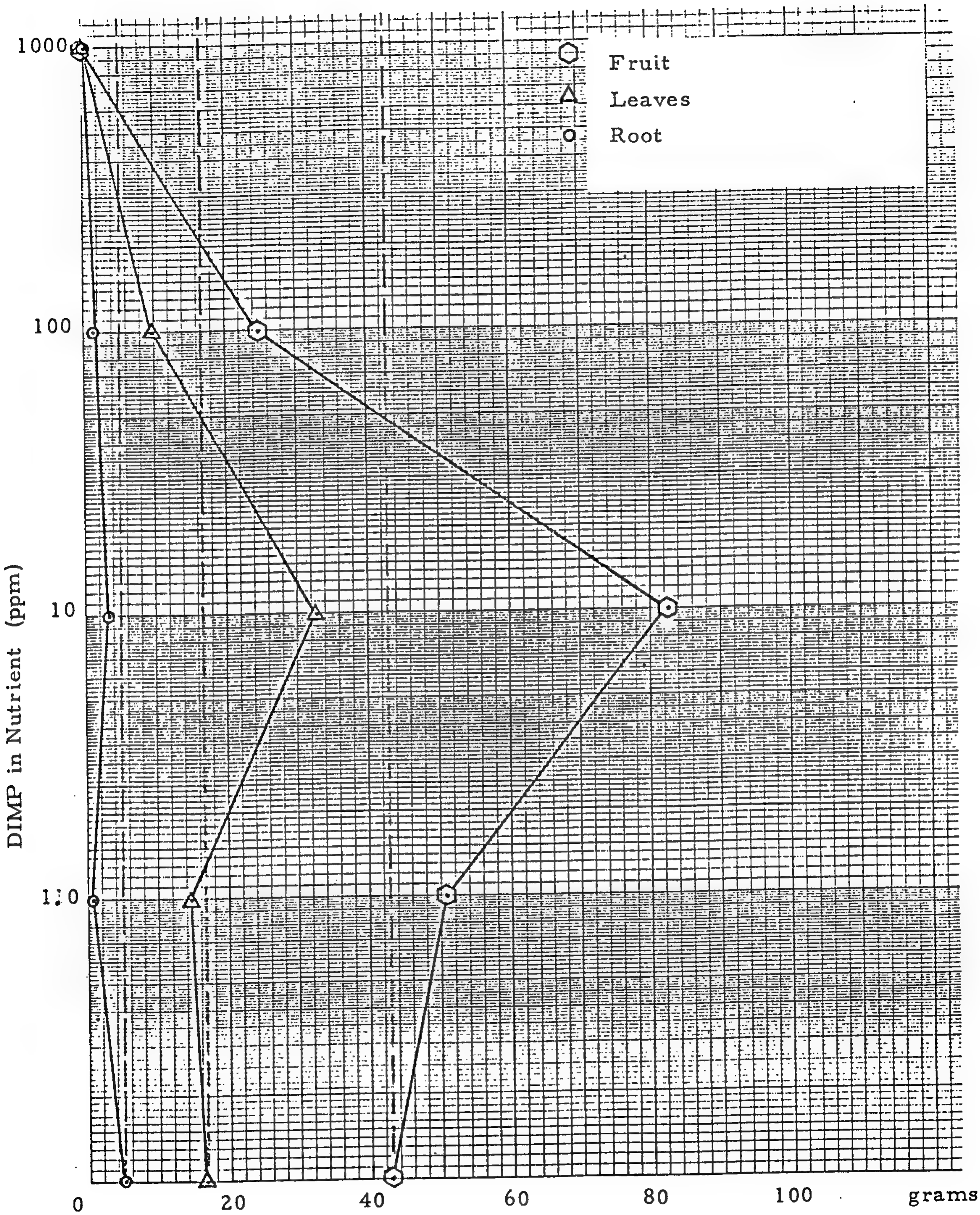

Figure 7 Yield of Radish Plants from Various Nutrient Levels of DIMP Contamination

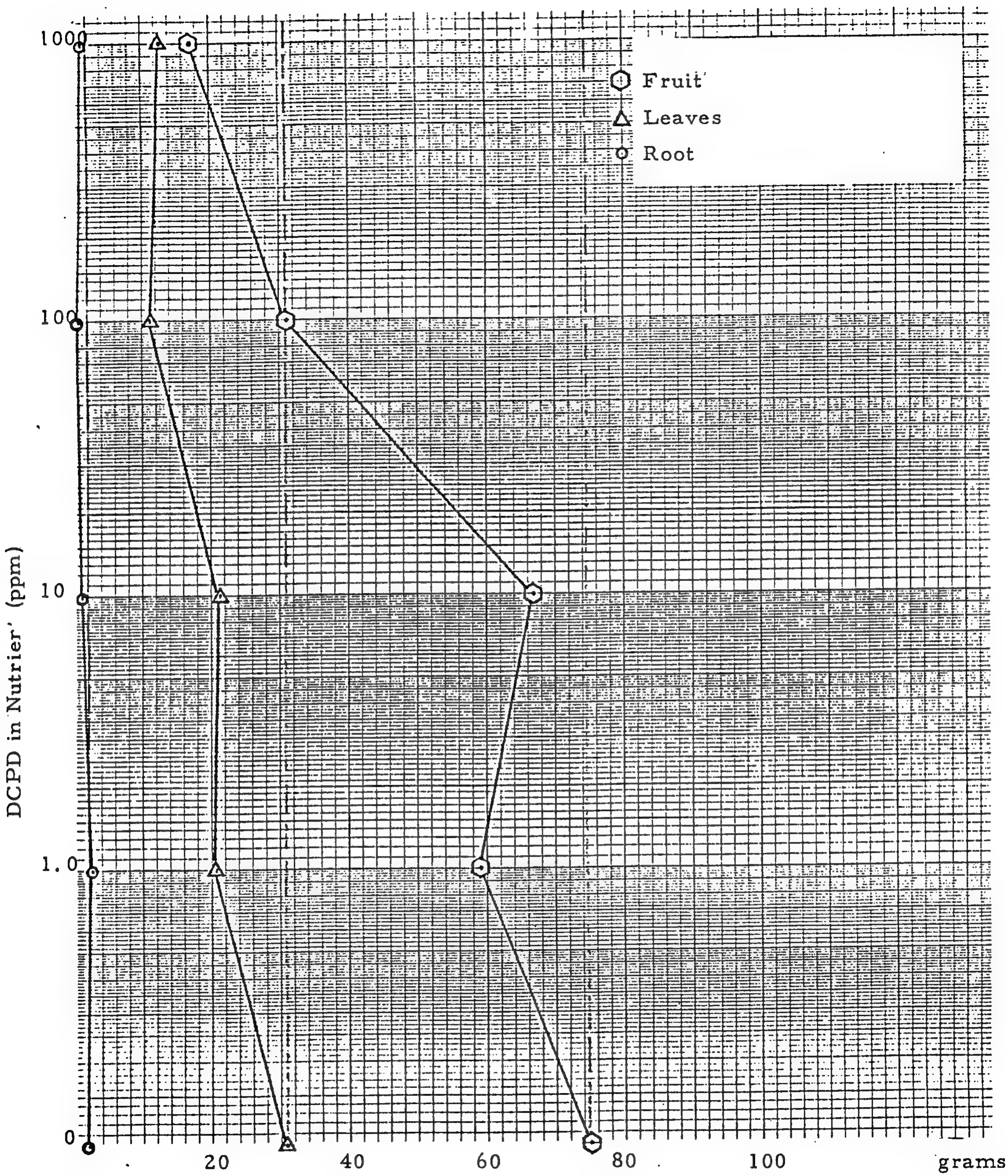

Figure 8. Yield of Radish Plants From Various Levels of DCPD Contamination.

Table V

DIMP Content of Radish Parts After 28 Days Exposure

Plant Part	Conc. of DIMP in Nutrient (ppm)	Conc. of DIMP in Plant (ppm)	Bioaccumulation Factor
Leaf	1.0	12.05	12X
"	10	48.3	4.8X
"	100	957.6	9.6X
" *	1000	5231	5.2X
Fruit	1.0	0.3	0.3X
"	10	7.3	0.7X
"	100	175	1.8X
" *	1000	1000	1.0X
Root	1.0	2.3	2.3X
"	10	9.7	1.0X
"	100	109	1.1X
" *	1000	2935	2.9X

* 22 Days Exposure

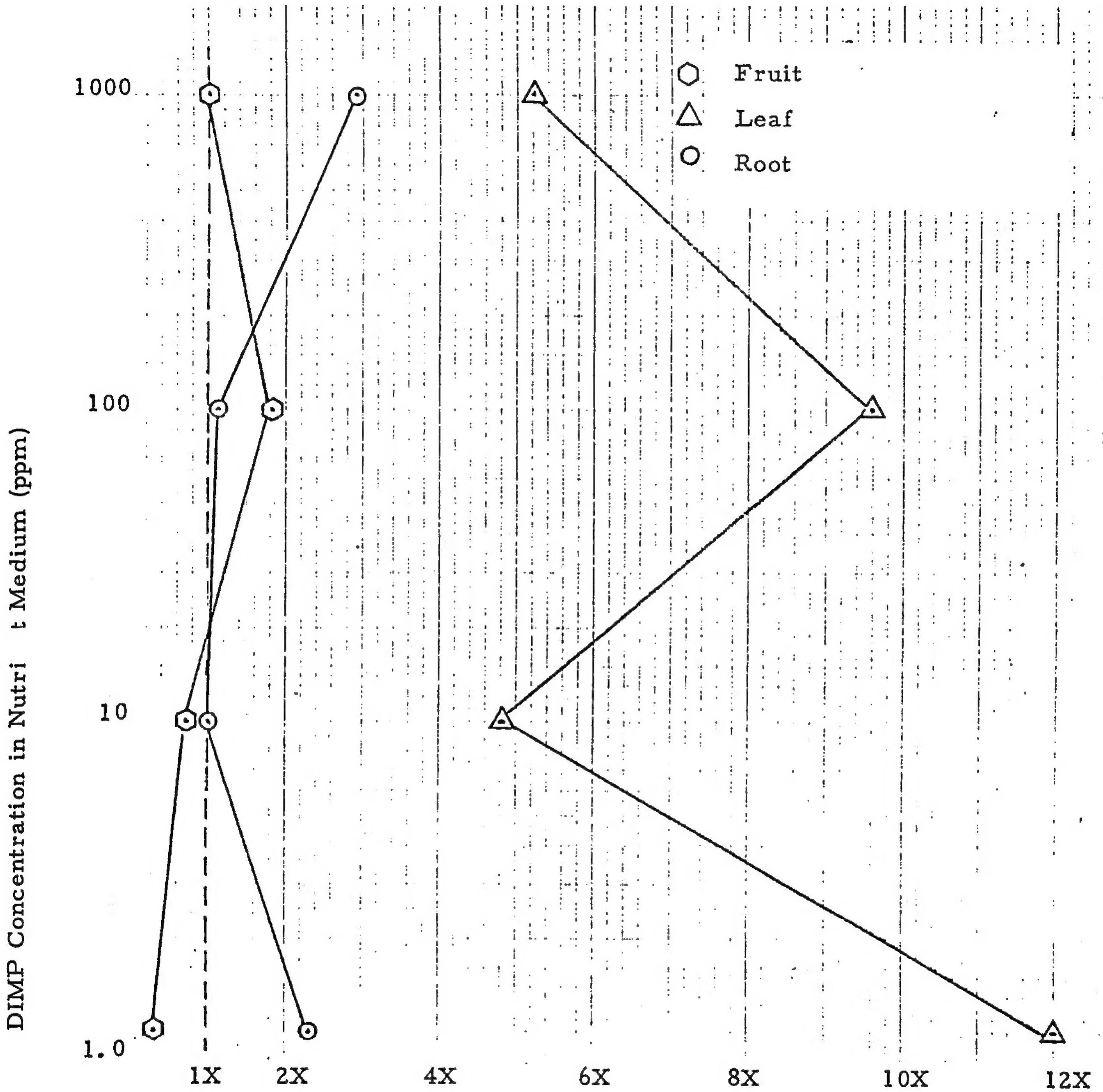

Figure 9. Bioaccumulation of DIMP in Radish Parts at Maturity.

Visual examination of the remaining plants after 44 days exposure of DIMP yielded the following observations:

Plant	Concentration	State
Tomato	100 ppm	Advanced necrosis
Corn	"	Larger than control, healthy
Bean	"	Stunted with some necrosis
Fescue	"	Stunted
Sugar Beet	"	Stunted
Carrot	"	Healthy
Rose	"	Extreme necrosis
Wheat	"	Larger than control, limited leaf burn
Juniper	"	Healthy
Tomato	10 ppm	Larger than control, healthy
Corn	"	Larger than control, healthy
Bean	"	Healthy, individual beans larger than control
Fescue	"	Healthy
Sugar Beet	"	Larger than control, some leaf burn
Carrot	"	Larger than control
Rose	"	Leaf chlorosis
Wheat	"	Larger than control
Juniper	"	Healthy
All Plants but Juniper	1 ppm	Slightly larger than control, healthy
Juniper	"	Healthy

After 39 days exposure to DCPD the following observations were made:

In the 1000 ppm DCPD nutrient all plants except the juniper were somewhat stunted. The corn and rose in addition had browning of the leaves. In the 100 ppm DCPD nutrient the corn and roses also demonstrated chlorosis of the leaves, all other plants except the juniper were larger than the control, the juniper was similar to the control. In the 1 ppm DCPD nutrient all plants were similar to the control plants.

These observations generally follow the quantitative data generated so far. The differences in effect of DIMP and DCPD can be partially ascribed to the lack of solubility of the DCPD in the nutrient medium. In these tests solubilization of the DCPD by addition of other species (e.g. alcohols) has been avoided to eliminate further complicating factors. These tests are continuing.

SOIL CULTURE

Dr. App indicated in his recent visit that soil culture may be preferable to hydroponic culture in some of the future experiments on this program. Consequently a soil mix was formulated and limited seeding tests of all the plants except juniper and rose have been initiated. All plants appear to be healthy and growing in the soil after two weeks.

ADDED PLANT TYPE

In the most recently revised protocol the plant groupings have been modified and an additional group, aquatic plants, has been added. From this group we have selected rice as our test plant. This selection was based partially upon the availability of rice seed and rice technology in the California area.

Several types of rice seed have been supplied to us along with information relative to their nutritional needs and planting procedures by Mr. Kenneth E. Mueller, Farm Advisor at the University of California Agricultural Extension Service of Colusa County. Colusa County is in the center of the California rice growing area. Germination tests are currently underway on these seeds.

RADIOACTIVE MATERIAL PROCUREMENT

The California State Health Department, Radiologic Section has granted AOMC a license to possess 40 millicuries of Carbon-14 for use in plant tracer studies. This is License Number 1450-59, Amendment 6. An order has been placed with New England Nuclear Corporation for both DIMP and DCPD containing ^{14}C.

PROPOSED ACTIVITY DURING DECEMBER 1975

During the coming month the following activities will be pursued:

- Continue analysis of the range finding plant growth experiments as the plants reach maturity.
- Inoculation of full scale lysimeters and analysis of agent mobility in the lysimeters.
- Continue laboratory scale soil/additive experiments.
- Work up future test plans based on most recent protocol.
- Continue search for more sensitive DCPD analysis in soil and plant extracts.